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ARIZONA GEOLOGICAL SURVEY
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MISSION

To provide unbiased information to the public to enhance understanding of geologic processes, materials, and resources and support prudent management and use of Arizona's land, water, mineral, and energy resources.

FUNCTIONS

- *Provide information about Arizona geology*
- *Map and describe bedrock and surficial geology*
- *Map and characterize mineral and energy resources*
- *Investigate geologic hazards and limitations*
- *Prepare and publish geologic maps and reports*
- *Maintain databases and files*
- *Maintain geology library*
- *Maintain rock cuttings and core repository*
- *Provide administrative and staff support for Oil and Gas Conservation Commission*

A.R.S. § 27-152

Seismic Hazard in the Flagstaff Area

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Arizona Geological Survey

Geologic investigations of young faults (paleo-seismology) provide information about large prehistoric earthquakes that can be used with the historical seismic record to evaluate potential for damaging earthquakes. Historical seismic activity and the geologic record of young faulting suggest that there is significant seismic hazard in the Flagstaff area. Flagstaff has been shaken by moderate earthquakes in the past century, the largest of which was around magnitude 6. Many faults in the area have been active in the past several million years and may have potential to generate large quakes. To evaluate the seismic hazard, we conducted a detailed paleoseismologic study of the Bellemont fault, 10 miles west of downtown Flagstaff and gathered information on other young faults in the area.

The Bellemont fault, probably representative of many of the potentially active faults in the area, has experienced repeated ruptures throughout the past few million years. About 12 m of slip has occurred along it during the past 500,000 years. Based on interpretation of a trench excavated across the fault, we concluded that about 2 m of slip occurred in the youngest fault rupture. This rupture, which occurred about 10,000 to 100,000 years ago, likely generated a magnitude 6.6 to 7.0 earthquake. On average, a large quake occurs on the Bellemont fault every 50,000 to 100,000 years. Even though the probability that a large earthquake will occur during a time frame as short as the next 50 years is very low, a large earthquake could occur on the fault at any time.

High concentrations of faults that have been active in the past 5 million years exist south of Flagstaff and north of the San Francisco Mountains. During the past 500,000 years or so, 17 faults

*see **SEISMIC HAZARD**, page 3*

Figure 1. *View looking north along the Bellemont fault on Camp Navajo. In the foreground two strands of the fault drop the land surface on the left (west) side of the photo down relative to the right side. The prominent fault scarp formed on the middle Pleistocene Headquarters basalt flow is evident just to the left of the water tower (arrow). The Bellemont fault extends to the north, where it forms a high, gentle scarp on the horizon on the right side of the photo.*

Mesa Quadrangle Finished

Arizona Geology

is published quarterly by the Arizona Geological Survey (AZGS) to provide information about geologic materials and processes and their impacts on the development and use of Arizona's land, water, mineral and energy resources. We encourage your comments and suggestions.

Design and layout:
Peter F. Corrao

Bedrock geologic mapping began two years ago in the Mesa 30' x 60' Quadrangle under the STATEMAP program, wherein Federal and State dollars are matched and used by State geological surveys to produce new geologic maps of areas given priority by the States and by State Geological Mapping Advisory Committees. In Arizona this committee includes 26 members from geologic consulting and exploration businesses, government agencies, and universities. The Mesa Quadrangle includes part of the rapidly growing Phoenix metropolitan area and a major concentration of porphyry copper deposits in the Globe-Superior-Ray area.

Mappers completed four 1:24,000-scale geologic maps within the Mesa 30' x 60' Quadrangle during the 1995-1996 field season (Figure 2). Three were released as Open-File Reports (OFRs 96-8, -9, and -10) and the fourth, the North Butte Quadrangle east of Florence, is being drafted. A 1:100,000-scale map of the Mesa 30'x 60' Quadrangle, based in part on the new 1:24,000-scale maps, was then produced and released as OFR 96-23. These maps complete our objective to cover the Mesa 30' x 60' Quadrangle, except for the interior of the Superstition Mountains Wilderness Area, with 1:24,000-scale bedrock geologic maps.

New geologic mapping of the Theodore Roosevelt 30' x 60' Quadrangle has begun for the 1996-1997 field season. Bedrock geologic maps of the north side of the Superstition Mountains downstream from the Roosevelt Dam will be produced under the STATEMAP program. STATEMAP funds will also be used to map the surficial geology of the southwest side of the Mazatzal Mountains and lower Verde River Valley. Geologic maps of the Cave Creek and northern Paradise Valley areas are being made with funds from the U.S. Environmental Protection Agency to help avoid potential indoor-radon problems in buildings constructed on rocks with elevated concentrations of uranium. Radon is a natural decay product of uranium. These 1:24,000-scale geologic maps will represent a major expansion in coverage of the Theodore Roosevelt 30' x 60' Quadrangle. This mapping should be completed in 1999.

Since 1983 Arizona Geological Survey geologists have also completed and released the Little Horn, Salome, Phoenix North, and Phoenix South 30' x 60' Quadrangles.

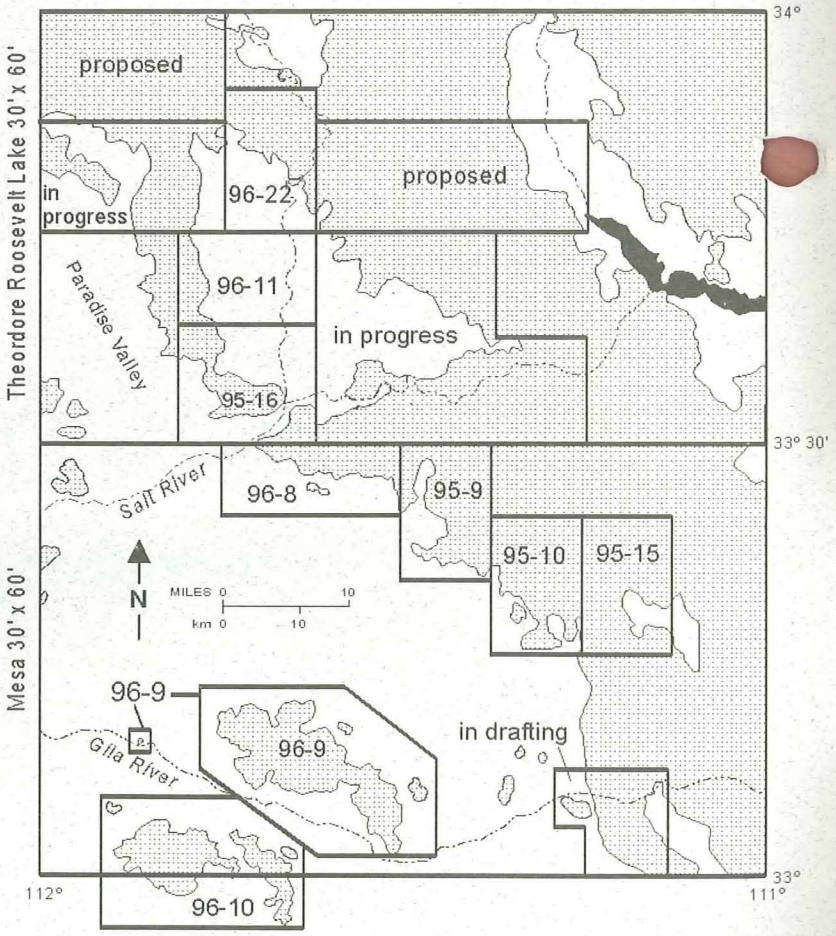

Figure 2. *Status of 1:24,000-scale geologic maps produced, in progress, or proposed as part of the STATEMAP program for the Mesa (south half of figure) and Theodore Roosevelt Lake 30' x 60' Quadrangles. Numbers indicate AZGS Open-File Reports.*

New Publications

Seismic Hazard

(continued from page 1)

have likely ruptured at least once and about 20 more faults may have ruptured. Typical intervals between surface ruptures on individual faults are probably at least 100,000 years. Using this information, we infer that a large earthquake occurs *on average* every 2,000 to 5,000 years in the Flagstaff area.

A new seismic hazard assessment of the area was developed. We used several alternative assumptions about fault behavior and background seismicity to develop probabilistic hazard scenarios. Results of these analyses imply that seismic hazard in Flagstaff is moderate. Large earthquakes occur in this region, but not frequently enough to result in high probabilistic accelerations over short exposure periods.

These investigations and analyses are summarized in Arizona Geological Survey (AZGS) **Bulletin 200**, which is announced in the next column. This work was supported cooperatively by the AZGS, the Federal Emergency Management Agency, and the Arizona Department of Emergency and Military Affairs.

The Arizona Geological Survey released the following reports and maps since September 1996:

Plio-Quaternary faulting and seismic hazard in the Flagstaff area, northern Arizona: P. A. Pearthree, K. R. Vincent, R. Brazier, and D. M. Hendricks, 1996, Arizona Geological Survey Bulletin 200 (Pub. number B-200), 31 p., 2 plates, scale 1:50,000 and 1:100,000. $20.00

The content of this report is described in detail on page 1.

Geology and geophysics of the Cienega basin area, Pima and Cochise Counties, Arizona: S. M. Richard and R. C. Harris, 1996, Open-File Report 96-21 (Pub. number OFR 96-21), 37 p., 4 plates, scale 1:100,000. $9.00

Geologic data for the lower Cienega basin area were compiled at 1:100,000 scale. Gravity and magnetic data were used in conjunction with the geologic data to construct four cross sections. A generalized isopachous map for low-density (inferred high porosity) basin fill was constructed from the cross sections.

Geologic map of the Bartlett Dam Quadrangle and southern part of the Horseshoe Dam Quadrangle, Maricopa County, Arizona: S. J. Skotnicki, 1996, Open-File Report 96-22 (Pub. number OFR 96-22), 21 p., 1 map, scale 1:24,000. $6.00

The center of the study area includes the volcanic hills of Brushy Mountain and dissected basin-fill deposits, which are well exposed in the southeastern corner of the area. Most of the northern part of the area is underlain by coarse-grained K-feldspar porphyritic granite, which has been eroded into a well developed pediment south of the drainage divide.

Geologic map of the Mesa 30' x 60' Quadrangle, east-central Arizona: J. E. Spencer, S. M. Richard, and P. A. Pearthree, compilers, 1996, Open-File Report 96-23 (Pub. number OFR 96-23), scale 1:100,000. $3.00

This 34 x 57 mile quadrangle in Maricopa and Pinal Counties includes much of Mesa, Tempe, and Chandler, as well as the Santan Mountains, portions of the Sacaton and Superstition Mountains, and a large mountainous area between Superior, Florence, and the Ray Mine. New 1:24,000-scale geologic maps produced under the STATEMAP program, and older U.S. Geological Survey geologic quadrangle maps, are the primary sources of geologic map data. Bedrock and surficial units, earth fissure zones, and radiometric ages of rocks are shown.

Geology of the Cholla Tank and northern third of the Hoodoo Well quadrangles, northern Kofa Mountains, Yuma and La Paz Counties, Arizona: S. J. Skotnicki and C. A. Ferguson, 1996, Open-File Report 96-24 (Pub. number OFR 96-24), 14 p., 1 plate, scale 1:24,000. $5.00

Lower Miocene volcanic rocks rest unconformably on Mesozoic granitoids, metavolcanics, and conglomerates, which crop out locally.

Oil and gas potential of pre-Permian strata, eastern Holbrook basin, Arizona: S. L. Rauzi, 1996, Open-File Report 96-25 (Pub. number OFR 96-25), 15 p. $3.00

The author describes the source-rock potential and thickness of Devonian, Mississippian, and Pennsylvanian strata along the southwestern margin of the Defiance-Zuni positive area. Two cross sections through the eastern Holbrook basin are included.

Surficial geologic map of the southern parts of the New River Mesa and Humboldt Mountain Quadrangles, Maricopa County, Arizona: P. A. Pearthree and K. A. Demsey, 1996, Open-File Report 96-26 (Pub. number OFR 96-26), 13 p., 1 plate, scale 1:24,000. $4.50

This map depicts the distribution of stream deposits and hillslope colluvium on the northeastern fringe of the Phoenix metropolitan area. The map area, which is just north of Carefree and Cave Creek, consists of rugged mountainous terrane, the valley of Cave Creek, and the northern part of a dissected bedrock pediment. Most of the bedrock at the surface in the mountains

has been weathered into hillslope colluvium, although relatively intact rock may be observed in gullies and bedrock knobs or ridges. Deeply weathered Precambrian granitic rocks have been eroded into a well developed pediment at the southern margin of the mapped area. The report also discusses potential geologic hazards in this area, including flooding, soil problems, rockfall, and debris flows.

Storage opportunities in Arizona bedded evaporites: J. T. Neal and S. L. Rauzi, 1996, Open-File Report 96-27 (Pub. number OFR 96-27), 16 p. $3.50

The authors discuss current Liquified Petroleum Gas storage in Arizona and describe seven areas in which bedded evaporites have potential for storage. Requirements and procedures for obtaining permits for storage wells are summarized.

Annual report of the Arizona Geological Survey, FY 1996 (July 1, 1995 to June 30, 1996): L. D. Fellows, 1996, Open-File Report 96-29 (Pub. number OFR 96-29), 26 p. $4.00

This report includes summaries of major information activities, investigations undertaken, oil and gas activities, personnel, and budget, including contracted projects. It also contains a partial list of AZGS customers; a summary of service provided by AZGS staff to the public and profession; and a list of geologic maps and reports that were completed.

Geologic map of the Ripsey Wash area, Pinal County, Arizona: W. R. Dickinson, 1996, Contributed Map 96-B (Pub. number CM 96-B), 7 p., 1 plate, scale 1:24,000. $2.50

This map shows the Ripsey Wash compound half graben, which occupies an elongate 15 km^2 area parallel to the Ripsey fault. This map represents a revision and update of previous mapping.

Geologic map of the summit area of House Mountain, Yavapai County, Arizona: R. F. Holm and J. H. Wittke, 1996, Contributed Map 96-C (Pub. number CM 96-C), 25 p., 2 sheets, scale 1:6,000. $9.00

House Mountain is a shield volcano with a broad range of rock types that were erupted onto faulted and eroded Paleozoic strata in the Verde Valley, about 7 miles south of Sedona. The volcano is unusual because the lava flows are differentiated hawaiite, mugearite, and benmoreite that constitute a mildly alkaline igneous-rock series.

Geology of the Rio Salado Development District, eastern part, Maricopa County, Arizona: T. L. Pewe and J. K. Drosendahl, 1985, Contributed Map 96-D (Pub. number CM 96-D), 1 sheet with text, scale 1:24,000. $3.00

The geology adjacent to the Salt River from east Mesa to the confluence of the Verde River consists of Precambrian granite (1.4 billion years) that is locally overlaid by Tertiary (18 million years) tuff, arkosic sandstone and conglomerate, and breccia. Numerous late Tertiary basalt dikes cut breccia and conglomerate. Patches of Salt River terrace gravel (1 to 2 million years) are present on both sides of the valley up to 190 feet above the river.

Geology of the western part of Coon Bluff, Rio Salado Development District, eastern part, Maricopa County, Arizona: T. L. Pewe and J. K. Drosendahl, 1985, Contributed Map 96-E (Pub. number CM 96-E), 1 sheet with text and five cross sections, scale1:2,400. $3.00

Tertiary deposits (17-22 million years) crop out in the map area. Coon Bluff is on the south side of the Salt River at the Verde River confluence.

The geology and production history of the Tract 11 and Tract 17 uranium mines, Navajo County, Arizona: W. L. Chenweth, 1996, Contributed Report 96-A (Pub. number CR 96-A), 10 p. $1.50

These mines, located in the Monument Valley area, are within channel deposits in the basal portion of the Shinarump Member of the Chinle Formation (Triassic) that were scoured into the underlying Moenkopi Formation.

How to Order Them

You may purchase publications at the AZGS office or by mail. Address mail orders to AZGS Publications, 416 W. Congress St., Suite 100, Tucson, AZ 85701. Orders are shipped by UPS, which requires a street address for delivery. All mail orders must be prepaid by a check or money order payable in U.S. dollars to the Arizona Geological Survey or by Master Card or VISA. Do not send cash. Add 7% sales tax to the publication cost for orders purchased or mailed in Arizona. Order by publication number and add these shipping and handling charges to your total order:

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Arizona Geology
Winter 1996

DTE-3 Wins FRYE Award

Figure 3. John Kempton (left), GSA representative, presents a plaque to Steven Slaff at the October 29 business meeting of the Association of American State Geologists (AASG), which was held in conjunction with the annual meeting of the GSA in Denver.

Land Subsidence and Earth Fissures in Arizona, written by Steven Slaff and published by the Arizona Geological Survey as Down-To-Earth 3 (DTE-3), received the John C. Frye Memorial Award in Environmental Geology for 1996 (Figure 3). The award is given annually to recognize the outstanding paper in environmental geology published by the Geological Society of America (GSA) or a State geological survey during the preceding three years. The paper must provide substantive information about a geologically based environmental problem or issue in a manner that is understandable and directly useable by geologists and other professionals.

DTE-3 includes a discussion of the cause of subsidence, effects of subsidence, the origin and development of earth fissures, and the effects of fissures on structures and natural systems. The report was dedicated to the memory of Cathy Schulten Wellendorf, who worked with subsidence and earth fissures prior to her death in 1988. Dr. Frye was director of the Kansas and Illinois State Geological Surveys, and an active member of the AASG, before he became Executive Director of the GSA. He believed that environmental geology reflects an attitude of mind and requires the application of the best and most sophisticated scientific work we are capable of doing to the problems of accommodating a rapidly shrinking living space and resource base to human needs.

Registration Update

Reappointment. Governor Fife Symington reappointed Frank S. Turek as the geologist member of the nine-person State Board of Technical Registration (SBTR), extending his term until June 1999. Turek works for Greeley and Hansen in Phoenix.

Telephone. The SBTR now has an in-state toll-free telephone number: 1-888-252-3456. Out-of-state callers may still reach the SBTR at (602) 255-4053.

Comparable experience. Prior to July 1996, applicants for registration were required to demonstrate that their professional work had been completed under the direct supervision of a professional registrant in the discipline in which registration was being sought. The law has been changed as follows: "By two-thirds majority vote the Board may allow an applicant except for an architect applicant to meet the requirements of subsection D of this section by crediting comparable experience satisfactory to the Board that the applicant attained without the direct supervision of a registered professional."

A geology applicant must remember that even though only one of the nine board members is a geologist, a two-thirds majority approval is needed. The other eight board members will review the application. The information provided must convince them that it is *comparable* experience. The applicant must provide documentation that the work was supervised by a person qualified to evaluate and supervise the applicant's professional work. If the work is determined to be comparable the work experience can be applied toward the 48 or 96 months needed to qualify for the Fundamentals or Professional examination.

We Make Digital Maps

In September, the Arizona Geological Survey (AZGS) began to prepare digital geologic maps. Recently hired Jennifer Thieme has completed line work and is now adding map-unit attributes for the Phoenix North (30' x 60') Quadrangle. The completed map will also include point data for structural measurements. Plans are to finish the Phoenix North, Phoenix South, Salome, and Little Horn (30' x 60') Quadrangles before June 30, 1997.

The digital maps will be released initially as Arc/Info export files. Other data formats may be used, depending on the needs of map users. Please direct your comments or questions about this program to Stephen Richard at the AZGS (e-mail srichard@ccit.arizona.edu).